



## **Retrospective analysis of 471 surgically treated zygomaticomaxillary complex fractures**

Blumer, Michael ; Kumalic, Sabina ; Gander, Thomas ; Lanzer, Martin ; Rostetter, Claudio ; Rücker, Martin ; Lübberts, Heinz-Theo

**Abstract:** Purpose: Zygomaticomaxillary complex (ZMC) fractures are frequent in facial trauma; only fractures of the mandible are more common. Although the frequency of these fractures is geographically consistent, the aetiology differs widely among countries and even regions. Differences in socio-economic status and the ageing population seem to be two causes. This retrospective epidemiological study evaluates patients who were surgically treated for ZMC fractures at a Swiss university clinic. Materials and Methods: This study included 471 patients who were surgically treated for ZMC fractures in an oral and maxillofacial surgery clinic at a Swiss university hospital between January 2004 and December 2012. Complicated fractures such as LeFort II/III and bilateral ZMC fractures were excluded. Data on gender, age, and type of trauma were recorded. Fractures were classified by aetiology: motorised road traffic (car or motorcycle), bicycle, interpersonal violence, sports, falls (both less than and greater than 3 m in height) and other causes. Results: A total of 350 patients were male (74%), and 121 were female (26%). The ZMC fractures were most likely to occur in the third decade (117 cases, 25%). A predominance of male patients was found in the young age groups, but an equal ratio was found in the elderly groups. Etiologically, falls of less than 3 m were the most common cause of ZMC fractures (125 cases, 27%). Interpersonal violence was second (88 patients, 19%); male patients dominated this group, which had a male-to-female ratio of 21:1. A predominance of male patients was found in every subdivision when analysing by aetiology and gender. The lowest proportion of males (57%) was found for falls of less than 3 m. Conclusion: In our study, interpersonal violence and falls outnumbered road traffic accidents among causes of maxillofacial fractures. This is probably a consequence of strict road and work laws. Additionally, the older and more active populations accounted for the highest proportion of falls, and young male patients were the predominant victims of ZMC fractures.

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Retrospective analysis of 471 surgically treated zygomaticomaxillary complex fractures

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## **Summary**

**Purpose:** Zygomaticomaxillary complex (ZMC) fractures are frequent in facial trauma; only fractures of the mandible are more common. Although the frequency of these fractures is geographically consistent, the aetiology differs widely among countries and even regions. Differences in socio-economic status and the ageing population seem to be two causes. This retrospective epidemiological study evaluates patients who were surgically treated for ZMC fractures at a Swiss university clinic.

**Materials and Methods:** This study included 471 patients who were surgically treated for ZMC fractures in an oral and maxillofacial surgery clinic at a Swiss university hospital between January 2004 and December 2012. Complicated fractures such as LeFort II / III and bilateral ZMC fractures were excluded. Data on gender, age, and type of trauma were recorded. Fractures were classified by aetiology: motorised road traffic (car or motorcycle), bicycle, interpersonal violence, sports, falls (both less than and greater than 3 m in height) and other causes.

**Results:** A total of 350 patients were male (74%), and 121 were female (26%). The ZMC fractures were most likely to occur in the third decade (117 cases, 25%). A predominance of male patients was found in the young age groups, but an equal ratio was found in the elderly groups. Etiologically, falls of less than 3 m were the most common cause of ZMC fractures (125 cases, 27%). Interpersonal violence was second (88 patients, 19%); male patients dominated this group, which had a male-to-female ratio of 21:1. A predominance of male patients was found in every subdivision when analysing by aetiology and gender. The lowest proportion of males (57%) was found for falls of less than 3 m.

**Conclusion:** In our study, interpersonal violence and falls outnumbered road traffic accidents among causes of maxillofacial fractures. This is probably a consequence of strict road and

work laws. Additionally, the older and more active populations accounted for the highest proportion of falls, and young male patients were the predominant victims of ZMC fractures.

**Keywords:** maxillofacial fracture, zygomaticomaxillary complex fracture, aetiology, epidemiology

## **INTRODUCTION**

Facial trauma comprises a substantial proportion of all trauma cases. In the literature, 5% to 33% of major trauma patients suffered maxillofacial injuries (Hayter et al., 1991; Down et al., 1995; Shahim et al., 2006). Zygomaticomaxillary complex (ZMC) fractures are frequent; only mandibular fractures are more common (Boffano et al., 2015). Not or insufficiently reduced fractures of the zygomatic complex may lead to noticeable asymmetry of the face, which can result in problems in the social environment. Therefore correct reduction and internal fixation of these fractures is crucial.

Although the distribution of fracture patterns seems to be similar in various trauma centres, the aetiology differs, depending mostly on socio-economic factors of each country. Some common causes are road traffic accidents, interpersonal violence, falls, sports injuries and work injuries. (Naveen Shankar et al., 2012; Boffano et al., 2015). Epidemiological analyses are important for planning preventive measures or distribution of resources as many countries try to lower health costs while maintaining good public health. This applies especially with the ageing populace in Central Europe.

This retrospective study evaluates all patients who were surgically treated for ZMC fractures in an oral and maxillofacial clinic at a Swiss university hospital. The study's aim is to evaluate the demographic distribution and aetiology of ZMC fractures needing surgical therapy in a well-developed Central European country.

## **MATERIAL AND METHODS**

The clinical information system was searched for patients who had ZMC fractures and who underwent surgical treatment during the 9-year period from January 2004 through December 2012. Associated maxillofacial fractures as mandibular, LeFort I, nasal and orbital fractures were included, while complicated fractures such as LeFort II / III and bilateral ZMC or

isolated zygomatic arch fractures were excluded. Data on gender, age, and cause of trauma were recorded. In all, 471 patient cases were included in this study.

Computed tomography was the main diagnostic tool in most cases. However, whenever patients were referred by another hospital or by private practitioners, conventional radiographs or cone beam computed tomography could be used preoperatively.

Fractures were classified by aetiology: motorised road traffic (car or motorcycle), bicycle, violence, sports, falls (less than and greater than 3 m) and others (various aetiologies, including hits by items, hits by animals, and accidents with explosives)

Ethical approval was obtained from the responsible ethics committee at KEK Zürich (file sign: 2014-0479). The study design thereby fulfils the guidelines of the Declaration of Helsinki regarding ethical principles for medical research involving human subjects.

Statistical analyses were performed using Excel (Microsoft Corporation, Redmond, WA, USA) and the IBM SPSS Statistics program (Version 21, IBM Corporation, Armonk, NY, USA).

## **RESULTS**

Of the 471 patients, 350 were male (74%) and 121 were female (26%). This corresponds to an overall male-to-female ratio of 3:1. The mean age was 43 years (median: 40; range: 12 to 89). The mean age in the female population was 50 years (median: 50; range: 12 to 89), and the mean age in the male population was 40 years (median: 35; range: 15 to 85). This difference was significant.

In 230 (49%) of the cases, the right side was affected, and in 241 (51%) cases, the left side was affected.

The age group of 20- to 30-year-old patients was the largest, with a total of 117 (25%) cases. The groups for ages 30-40, 40-50 and 50-60 years followed, with 83 (18%), 76 (16%) and 73 (15%) cases, respectively (Fig 1). Subdividing these groups for gender, male patients



predominated in the young groups of age, but an equal gender ratio was found in the elderly groups (Fig 2). A total of 86 patients (18%) were 60 years or older.

The male-to-female ratio was highest in the age 20-30 group, at 12:1. The age 30-40 group was next-highest at 5:1. The ratios of the remaining groups varied from 1:1 to 3:1; 31% of all male patients were in the age 20-30 group, and female patients were most often in the age 40-50 and age 50-60 groups (22% and 24%, respectively).

Etiologically, falls of less than 3 m were the most common cause of ZMC fractures, with 125 cases (27%) (Fig 3). Next most common was interpersonal violence, with 88 (19%) cases.

Male patients dominated the latter group, which had a male-to-female ratio of 21:1. The sports group had the second highest gender ratio at 6:1 (Fig 4).

Analyses of the aetiology and gender of ZMC fractures revealed a predominance of male patients in every subdivision. The aetiology with the lowest male proportion turned out to be falls of less than 3 m (57%).

Isolated ZMC fractures were found in 283 (60%) cases. Most associated fractures occurred in the group road traffic (57%) and falls of over 3 m (50%). The most common associated fracture location was the orbit (depending on aetiology, 15.4% to 50%).

## **DISCUSSION**

In this study, the demographic distribution and aetiology of ZMC fractures was analysed. ZMC fractures occurred most frequently in the third decade. This finding is consistent with other studies and is explained by the high activity levels in this decade (Al Ahmed et al., 2004; Brasileiro et al., 2006; Gandhi et al., 2011; Lee, 2012; Mijiti et al., 2014; Gaddipati et al., 2015). In our study, patients between 20 and 30 years of age were predominantly involved in interpersonal violence, road traffic accidents and sports accidents.

Furthermore, in the third decade, there is an extremely high male-to-female ratio of 12:1. This ratio diminishes within the older groups, even reaching 1:1 (gender neutrality). This finding is

consistent with a Dutch study (Salentijn et al., 2013). One explanation for this finding might be the different aetiologies of the fractures found in the older groups. After the age of 40 years, falls of less than 3 m were the most common cause among those who received surgical treatment for ZMC fractures; this figure reached 70% in the eighth decade.

In absolute numbers, falls of less than 3 m were the most common fracture causes in this study (125 cases, 27%). Assaults (88 cases, 19%), traffic accidents (67 cases, 14%), bicycle accidents (65 cases, 14%) and sports injuries (62 cases, 13%) followed. These results differ partially from those in the literature, in which road traffic accidents have often been described as the primary cause of facial fractures (Al-Khateeb et al., 2007; Chrcanovic et al., 2012; Naveen Shankar et al., 2012; Mijiti et al., 2014). Other authors have found assaults and interpersonal violence to be the most common (Bakardjiev et al., 2007; Lee, 2012). The explanation for this discrepancy might be that the above-mentioned studies included panfacial fractures except for that of Chrcanovic et al. (Chrcanovic et al., 2012), which focused on mandibular fractures only, unlike this study, which concentrates on ZMC fractures. In addition, the previous studies were performed in developing countries that have varied socio-economic trends (e.g., Bulgaria, Korea, India, Jordan and China). In one study, Mijiti et al. (Mijiti et al., 2014) stated that economic status, population density and even cultural differences had a significant impact on the aetiology of facial trauma.

Furthermore, this study's findings are consistent with the results from a European multicentre study (Boffano et al., 2015), which confirmed a changing trend in maxillofacial trauma epidemiology in Europe, with assaults and falls outnumbering road traffic accidents. The authors attributed this finding to the progressive ageing of the populace and to consequent road legislation.

The authors of this study separated bicycle accidents from motorised traffic accidents due to the relatively high proportion of the former (14%). This finding could be due to the fact that bicyclists are less protected than, for example, automobile drivers. Head injuries occur in 33%

of bicycle accidents. Although helmets are not mandatory according to road legislation, authorities highly recommend wearing helmets, and statistically, 47% of bicyclists wear helmets. Nevertheless, the 65 cases over 9 years in which our department operatively treated ZMC fractures due to bicycle accidents is a small number compared to the more than 14,000 reported bicycle accidents in Switzerland each year (1987–2013).

If the bicycle accidents were added to traffic accidents, that group would be the most common cause of ZMC fractures in this study. Even though Switzerland has very good road conditions and strict road legislation, these findings seem to be consistent with studies from less developed countries. The differences probably lie in the absolute numbers. On the other hand, one could argue that a bicycle accident is not necessarily a traffic accident, as it could also be sports-related. In the end, the data from this study cannot present a final explanation regarding this topic.

The predominance of male patients in our study (with a ratio of 3:1) is well within the range given in the literature (with male-to-female ratios between 2:1 and 8:1) (Allareddy et al., 2011; Gandhi et al., 2011; Kostakis et al., 2012; Kraft et al., 2012; Lee, 2012; Salentijn et al., 2013; Mijiti et al., 2014; Boffano et al., 2015). In the European Maxillofacial Trauma (EURMAT) study, Boffano et al. stated that a tendency toward higher male-to-female ratios was seen in Eastern European countries relative to Western European ones (Boffano et al., 2015). They found that, in countries with an assault ratio of 40% or higher, men represented 80% of the patients. In our study, interpersonal violence accounted for 19% of the cases, which is consistent with the EURMAT results. Furthermore, male patients in our study accounted for 96% of the ZMC fractures due to interpersonal violence.

Kostakis et al. stated in their study that men are probably more frequently involved in social activities than women; therefore, men are thought to be more susceptible to traffic accidents, assaults and work accidents (Kostakis et al., 2012). The authors of the present study believe that this applies only partially to an equitable country such as Switzerland, where women and

men are equally active in social activities. Compared to women, men more frequently work in manual jobs (e.g. as a construction labourer or farmer) and exhibit physically more aggressive behaviour (especially among younger men), which is probably the most substantial explanation for the gender distribution of ZMC fractures.

The mean age of the female patients was significantly higher than that of the male patients. This finding is also consistent with the literature (Boffano et al., 2015). The ageing of the European population and the better health conditions of ageing adults (as well as the subsequent increased activity) are the origins (Gandhi et al., 2011; Lee, 2012).

Most analysed ZMC fractures were isolated ones. Analysis of associated fractures reveal that the aetiology road traffic is predominant, furthermore it is most frequently in all four included additional fracture sites. This may be explained through the mechanism of the injury and is consistent with the literature (Trivellato et al., 2011). Orbital fractures were most common when analysing associated fracture sites. This is not consistent with literature that mentions mandible and nose fractures (Ellis et al., 1985) or Le Fort and mandible fractures (Trivellato et al., 2011) to be most common. Remembering the mechanism of a ZMC fracture, the orbit should be affected in most cases; hence the zygoma is part of the orbital floor. Not or minimally dislocated orbital fractures are almost exclusively detectable on computed tomography with thin slices, and therefore it is possible that orbital involvement was underestimated in other studies. Another explanation for this discrepancy certainly is the use of other inclusion criteria for the studies.

A limitation of the study is its retrospective character, which can lead to bias. However, we believe that this limitation is clearly outweighed by the large number of patients (and thus ZMC fractures) that could be evaluated because of the retrospective design.

A further drawback is the lack of a classification for the ZMC fractures. This could have pointed out some more details in aetiology or impact of age. However, all patients needed surgical therapy, which may imply that all fractures involved dislocation.

In our study, for the aetiology of maxillofacial fractures, interpersonal violence and falls outnumbered road traffic accidents, as in the EURMAT study (Boffano et al., 2015). This may be a consequence of strict road and work laws. In addition, the population is ageing, which means that falls are becoming more frequent. However, young male patients are still the predominant victims of ZMC fractures, both in our study and in the literature (Al-Dajani et al., 2015).

### **CONCLUSION**

In this study, interpersonal violence and falls outnumbered road traffic accidents among the aetiologies of maxillofacial fractures. This is probably a consequence of strict road and work laws. Additionally, the ageing and increasingly active population helps account for the higher number of falls. Young male patients are the predominant victims of ZMC fractures, regardless of the cause.

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ACCEPTED MANUSCRIPT

**Figure 1.** Analysis of zygomaticomaxillary complex (ZMC) fractures by age group.

**Figure 2.** Analysis of zygomaticomaxillary complex (ZMC) fractures by age and gender.

**Figure 3.** Zygomaticomaxillary complex (ZMC) fracture analysis by aetiology (numbers of cases).

**Figure 4.** Analysis by age and aetiology.

**Table 1.** Analysis of associated fractures by aetiology.

<<table footnote>>Not included are aetiologies that were combined in the group “other.”

Absolute numbers are shown in bold type, and percentages of the aetiology groups are shown in parentheses.

	no additional fracture	orbital fracture	Le Fort I fracture	mandibular fracture	nasal fracture
<b>falls &lt; 3 m</b>	<b>82</b> (65.6)	<b>28</b> (22.4)	<b>12</b> (9.6)	<b>11</b> (8.8)	<b>8</b> (6.4)
<b>violence</b>	<b>58</b> (66)	<b>16</b> (18.2)	<b>5</b> (5.7)	<b>5</b> (5.7)	<b>4</b> (4.5)
<b>road traffic</b>	<b>29</b> (43.3)	<b>17</b> (25.4)	<b>15</b> (22.4)	<b>14</b> (20.9)	<b>10</b> (15)
<b>bicycle</b>	<b>45</b> (69.2)	<b>10</b> (15.4)	<b>11</b> (17)	<b>8</b> (12.3)	<b>4</b> (6.2)
<b>sports</b>	<b>42</b> (67.7)	<b>15</b> (24.2)	<b>5</b> (8)	<b>3</b> (4.8)	<b>2</b> (3.2)
<b>falls &gt; 3 m</b>	<b>5</b> (50)	<b>5</b> (50)	<b>0</b>	<b>2</b> (20)	<b>2</b> (20)

Fig 1

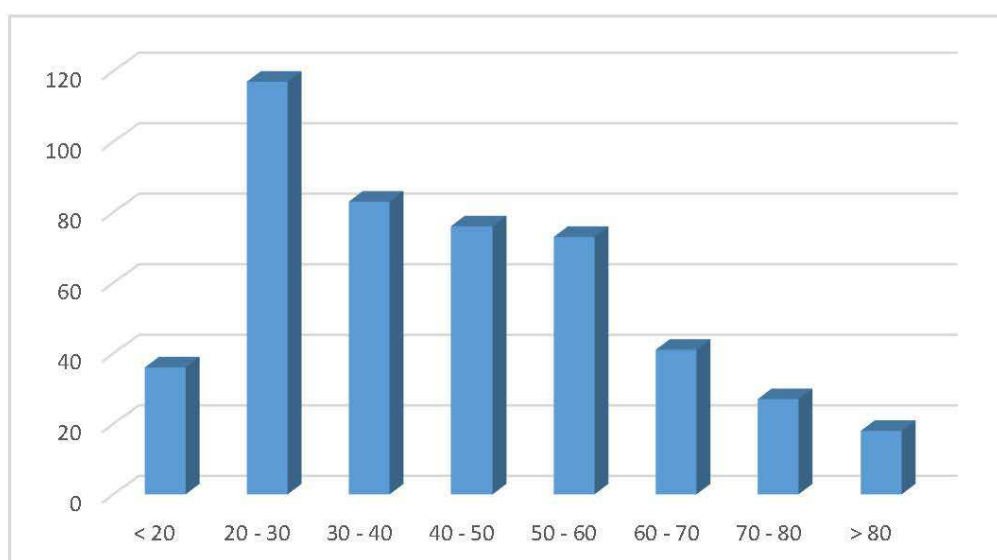


Fig 2

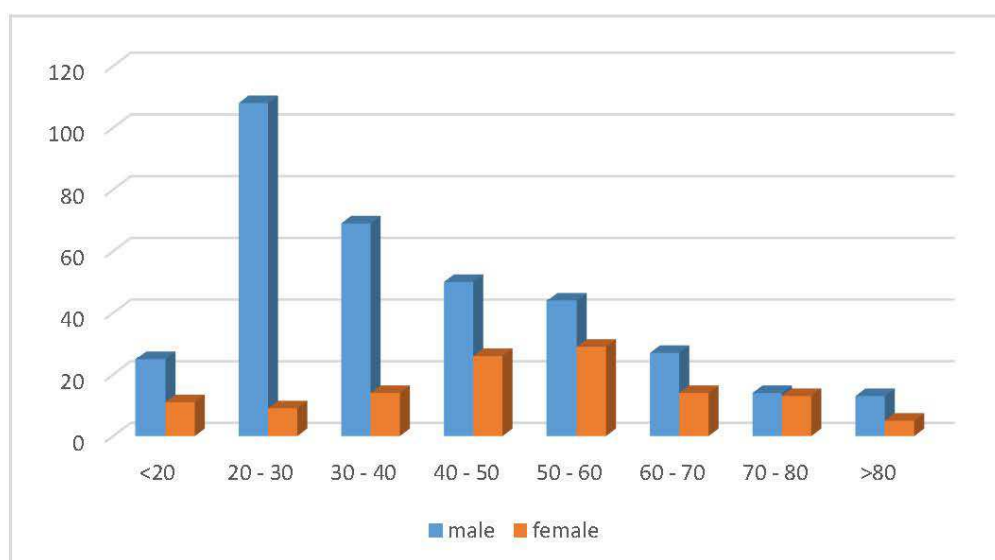


Fig 3

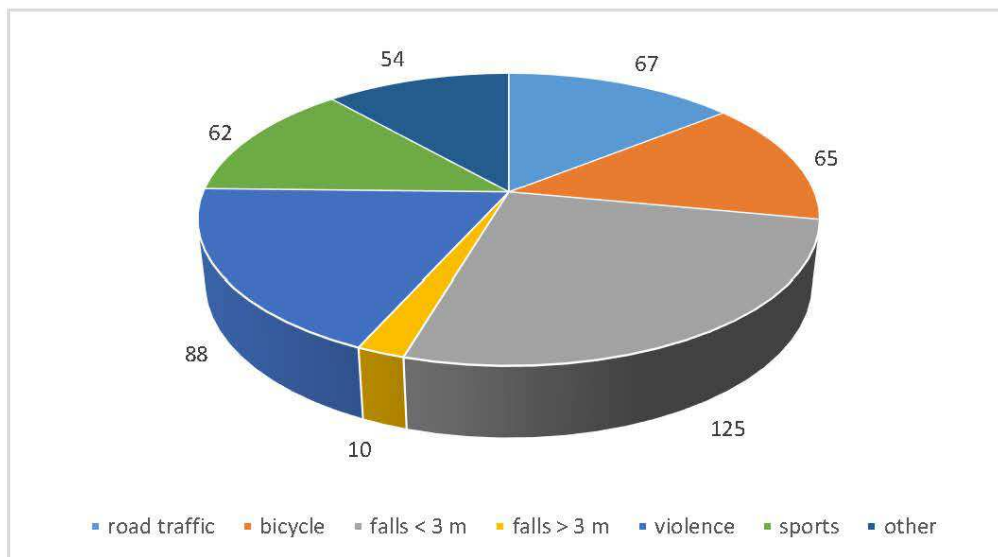


Fig 4

